Forest Health Management

USDA United States Department of Agriculture

Renewable Resources
Forest Health Management

Forest Service
Rocky Mountain Region
Denver, Colorado

BIOLOGICAL EVALUATION
R2-01-01

EVALUATION OF MOUNTAIN PINE BEETLE ACTIVITY ON THE BLACK HILLS NATIONAL FOREST

JANUARY 2001

PREPARED BY:

KURT K. ALLEN
Service Center Leader
Rapid City Service Center

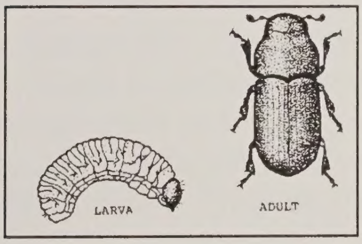
PREPARED BY:

JOEL D. McMILLIN
Entomologist
Rapid City Service Center

APPROVED BY:

FRANK J. CROSS
Group Leader
R2, Forest Health Management

Renewable Resources
USDA Forest Service
Rocky Mountain Region
740 Simms Street
Golden, CO 80401



ABSTRACT

Mountain pine beetle populations have been increasing in the Black Hills over the last 3 years. In 1998, 1999, and 2000, aerial surveys have detected a large mountain pine beetle infestation in the Beaver Park area on the Northern Hills Ranger District. Ground surveys found 41.4 trees per acre killed on average over the last 3 years, with approximately 61% of these trees being currently infested. Also, brood sampling continues to indicate that beetle populations are still increasing in the area. Three years ago nearly 70% of the forested land in the Beaver Park area was classified in the moderate to high stand susceptibility categories. Stand susceptibility is being reduced as much of the basal area has been decreased by beetle-caused tree mortality. However, because there has been no treatment, there continues to be epidemic mountain pine beetle populations and associated high levels of tree mortality in the Beaver Park area. In addition to the mountain pine beetle situation in Beaver Park, pockets of beetle-killed trees have been detected from aerial survey in the Bear Mountain and Steamboat Rock areas. Ground surveys in these areas found an average of 8.2 and 7.3 trees per acre killed over the last 3 years, respectively. More than 45 % of these trees are currently infested. Brood sampling in both areas suggest beetle populations are increasing. Relatively few currently infested trees were found in the Pactola Lake, Sheridan Lake, and Deerfield Recreation Areas.

Strategies for dealing with the mountain pine beetle include: do nothing, silvicultural treatments, sanitation/salvage harvesting, infested tree treatment, and individual tree protection. Although the part of the Beaver Park area that has been classified as roadless is off limits to treatment, a full range of treatments should be considered in the surrounding areas to limit the continued expansion of the mountain pine beetle epidemic in this area. Similarly, a combination of silvicultural treatments and sanitation harvesting or mechanical treatment is recommended for the Bear Mountain and Steamboat Rock areas. Continued sanitation removal of infested trees within the recreation areas is recommended.

INTRODUCTION

Mountain pine beetle (*Dendroctonus ponderosae*) is the number one insect killer of pines throughout the western United States. The beetle is a native species to the West and attacks most pine species including ponderosa pine in the Black Hills.

The mountain pine beetle has one generation per year in the Black Hills. Adult flight typically occurs in July - August, when adults leave previously infested trees and attack uninfested, green trees. The adults attack green trees, chew through the bark and construct galleries along which eggs are laid. Larvae hatch from the eggs and begin feeding on the phloem of the tree in late summer to early fall. Larvae, pupae or callow adults overwinter under the bark of the infested tree. In the Spring, the beetle finishes its maturation process, producing the next generation of adults.

Populations of the mountain pine beetle are usually found at an endemic level, killing and reproducing in stressed or weakened trees, including lightning struck and root diseased trees. Less than one tree per acre per year killed is considered to be an endemic level. For reasons that are not fully understood, beetle populations can increase dramatically. In the increasing and epidemic stages, healthy trees are attacked and killed along with stressed trees. In 1999, areas of Beaver Park had tree mortality ranging between 83 trees per acre to 1 tree per acre killed over a 3-year span (Allen and McMillin 1999).

Mountain pine beetle has always been a part of the Black Hills forest ecosystem, with outbreaks occurring periodically. The first recorded outbreak in the Hills occurred from the late 1890's through the early 1900's and killed an estimated 1-2 billion board feet of timber. Outbreaks also have occurred in the 1930's, 1940's, 1960's and 1970's, each lasting 8-13 years with the 1970's outbreak being larger and causing more mortality than any of the others, except for the turn of the century outbreak. The most recent outbreak occurred from 1988-1992 in the Bearhouse Area on the Harney Ranger District and ended up killing over 50,000 trees (Pasek and Schaupp 1992). Outbreaks of the beetle can cause considerable changes in forested stands, including a reduction in average stand diameter and stand density (McCambridge et al. 1982). Tree mortality levels of 25% can be expected throughout the landscape surrounding outbreak areas and levels of up to 50% or more can occur in heavily attacked stands (McCambridge et al. 1982). Outbreaks can conflict with land management objectives: they reduce timber stocking levels, affect wildlife habitat, increase short-term fire risks, and can negatively effect visual and recreation values (Samman and Logan 2000).

Susceptibility of pine stands to beetle attack can be categorized in the Black Hills. Generally stands are considered to be most susceptible when 75% of the stand is in the 7-13 inch diameter range and the stand density is over 120 feet of basal area per acre (Stevens et al. 1980, Schmid and Mata 1992). It should be noted that these are general hazard rating guidelines and most stand inventory data are based on stand averages; small pockets that have high stocking levels within a low density stand can be a focal point for beetle buildup. Stand hazard ratings give an indication of which stands are most likely to have initial beetle infestations. Once an outbreak has started, any stands

containing suitable host material are likely to incur damage. These ratings also give no indication of local beetle pressure. However, hazard ratings can help to prioritize what stands can be treated to minimize beetle susceptibility. It also points out the best approach to reducing losses to the mountain pine beetle for the long-term is forest management to reduce stocking densities. Decreases in stocking densities will lower the probability that beetle outbreaks will be initiated, but it is a continual process to keep stands in the low risk category. Recent work has shown that areas treated to 60 basal area can be expected to reach high hazard (120 basal area) again in about 25-50 years. Stands treated to 80 basal area can reach 120 basal area in 13-36 years, and stands treated to only 100 basal area will be back to 120 basal area in 9-16 years (Obedzinski et al. 1999). These timeframes of when a forest can increase in hazard level are relatively short, often shorter than the typical stand re-entry time interval.

Other forms of control of mountain pine beetle, such as natural enemies or environmentally related factors, are less predictable. Generally, when beetle populations reach outbreak proportions, natural enemies, such as birds and predaceous or parasitic insects, are not numerous enough to have a noticeable effect on the outbreak. Natural enemies are more important in limiting mountain pine beetle populations that are in the endemic phase (Bellows et al. 1998). Likewise, environmental factors cannot be counted on for lessening the outbreak. For example, temperatures of -10° F can kill beetles in October but temperatures of -25° are needed by February (Schmid et al. 1993). These temperatures need to be reached under the bark, in the phloem, as opposed to air temperatures. Beetles survive low temperatures by removing water from within their cells and replacing it with glycoproteins, which act as a type of anti-freeze (Bentz and Mullins 1999). This is a process known as cold hardening. Beetles have supercooling points, the temperature at which ice crystals start to form in body tissues, as low as -32° F in January (Bentz and Mullins 1999). Phloem temperatures become equal to air temperatures only when they persist for 24 hours or more (Schmid et al. 1993). Generally, phloem temperatures are found to be 5 to 10° F warmer than air temperature.

The focus of this evaluation is to examine the continuing beetle situation in Beaver Park and other areas of the Black Hills National Forest. The evaluation is based on aerial survey information, ground surveys, and brood sampling data. Potential action alternatives and recommendations for different management areas are presented.

METHODS

The current mountain pine beetle conditions for the Beaver Park and other areas of the Black Hills National Forest were estimated using aerial survey and aerial photography data, brood sampling, and ground transects to estimate beetle caused mortality, including green currently infested trees, over the last three years. Stand hazard ratings for the Beaver Park area using the RIS database were reported in 1998 and were not repeated (Allen and McMillin 1998). It is assumed that with the extensive tree mortality that overall the number of stands in the high and moderate classes have decreased.

An aerial survey was conducted in September 2000. The number of fading trees and their approximate location are mapped in this survey. These surveys detect pines that have been killed in the last 1-2 years and whose crowns have faded. Currently infested trees, whose crowns have not faded, cannot be discerned from the air. Conditions such as those found in Beaver Park, with large spots and amounts of mortality, make this type of survey difficult to map precise estimates of tree mortality. This being the case, the Beaver Park area also was aerially photographed this year using color infrared film. It is hoped that this procedure will allow a more accurate estimate of the actual number of trees killed and the exact location of mortality pockets.

Beaver Park

Brood sampling was carried out in November 2000 and January 2001 according to methods described by Knight (1960). A 6 x 6-inch piece of bark was removed from the north and south sides of currently infested trees. All live and dead brood in the pieces were counted. A total of 20 trees were sampled in the Kirk Hill area immediately west of Beaver Park and two locations along FR139. The numbers of brood found were totaled for each area. The number of brood per sample is used in a regression equation to indicate whether beetle populations are decreasing, increasing, or static.

Transect lines were run throughout the Beaver Park area in October 2000. Each transect line was approximately 1 mile long and 1 chain wide, covering an area of 8 acres per line (except where noted). Recently killed trees were tallied along each transect line. Attacked trees were broken into four categories: new beetle hits (year 2000 green attacked trees), one-year-old hits (1999), two-year-old hits (1998), and current pitchouts.

A total of 22 transect lines were run, covering 23.75 miles throughout the Beaver Park area, for a total of 190 acres evaluated. On each line, variable radius prism (BAF 10) plots were measured every ¼-mile. Diameter at breast height (DBH) was taken for all "in" trees in each plot. These measurements were used to provide an estimate of basal area (BA), DBH, and trees per acre (TPA) along the transect lines. The distribution of transects lines in the Beaver Park area is shown in Figure 1.

Bear Mountain

The 1999 and 2000 aerial surveys detected numerous small pockets of tree mortality to the south and west of Bear Mountain. A total of 4 transects were completed, covering 4 miles (30 acres) throughout this area. The assessment included areas adjacent to FS293 (Bear Mountain Lookout and Sourdough Draw). Using the methods described above, brood sampling along the FS293 was conducted in November 2000.

Steamboat Rock

The area around Steamboat Rock was evaluated through ground surveys in 1997 through 1999 (Allen 1998, Allen and McMillin 1998, McMillin and Allen 1999). As a result of the beetle situation, and because there was a planned timber sale in the area, the district re-evaluated the sale area changing volumes to be removed in a sanitation effort. Cutting and removal of infested trees was completed in June of 1998. This year's assessment covered much of the same ground as reported in Allen and McMillin (1998) and McMillin and Allen (1999). A total of 9 transects were completed, covering 9.75 miles (78 acres) throughout this area. The assessment included areas south of Nemo Road adjacent to Steamboat Rock picnic grounds, FS147.1A, and FS149. Using the methods described above, brood sampling along the Nemo Road was conducted in November 2000.

Pactola Lake & Sheridan Lake areas

For the Sheridan and Pactola Lake Recreation Areas, small pockets of beetle-caused tree mortality were noted in or very near each campground from the 2000 aerial survey. Ground surveys of campgrounds, day use, and surrounding areas were conducted in November of 2000 to determine the level of current beetle activity. Each campsite was visited along with an area about 60 feet into the forest surrounding each campground. Pockets of recently killed (1-year-old dead trees) and green, beetle infested trees were recorded. Also, unsuccessful attacks, or pitchouts, were noted.

Deerfield Lake Area

Ground surveys of campgrounds, day use, and surrounding areas were conducted in November of 2000 to determine the level of current beetle activity. Each campsite was visited along with an area about 60 feet into the forest surrounding each campground. Pockets of recently killed (1-year-old dead trees) and green, beetle infested trees were recorded. Also, unsuccessful attacks, or pitchouts, were noted.

RESULTS

During the mid-1990's, beetle mortality was light and scattered throughout the Black Hills. In 1997, there was a noticeable increase in mortality detected. The 1999 survey showed another sharp increase from 1998, with much of the heaviest damage concentrated into a few areas. The aerial survey from 1999 detected a total of 25,562 trees killed throughout the Black Hills. This is an increase from the 10,726 trees killed on National Forest lands in 1998. In 2000, the amount of mortality increased again to 38,262 trees. In all cases, much of the damage was concentrated in groups of 25 trees or more in a few areas. More than 60% of the total tree mortality recorded in the 1999 and 2000 aerial surveys was found in the Beaver Park area. Other areas sustaining concentrated pockets of tree mortality included Bear Mountain, Steamboat Rock, and areas west and south of Deerfield Lake.

Beaver Park

Results from brood sampling are shown in Figures 2, 3, and 4. Figure 2 represents brood that was developing from beetle attacks initiated in August 1999. Figures 3 and 4 represents brood developing from attacks occurring in August 2000. In all cases, the data confirm that mountain pine beetle populations are increasing in the Beaver Park area. A decrease in this year's brood is expected before beetle flight occurs in the Summer of 2001; however, the level of decrease is unknown. Natural enemies and competition with woodborer larvae feeding on the same food resource can cause brood mortality. The amount of mortality caused by weather factors, for example cold temperatures, is expected to be negligible, as the samples were taken in mid-November after low temperature extremes had occurred earlier in the fall and little larval mortality was noted. The January brood sampling along FR139 indicated that approximately 5 percent of larvae had died because of cold temperatures.

Table 1 lists the number of beetle-killed trees found on all transects for the 2000 ground survey in the Beaver Park area. Mortality from 1998, 1999, and green infested trees show that there is an average of 41.4 trees per acre killed throughout this area. This value is almost 3 times the number of trees killed per acre reported last year (16.1 trees killed per acre in 1999) (Allen & McMillin, 1999). Beetle populations were increasing 2.5 times in both 1998 and again in 1999; that is, there were approximately 2.5 green infested trees for every 1-year-old killed tree. The increase will be about the same again this year; approximately twice the number of dead trees will be present in 2001 as compared to 2000. The combination of increasing population and high number of trees being killed per acre characterize this area as being in an epidemic phase.

Table 2 lists the number of attacks by transects line in the Beaver Park area, and corresponding average basal area and diameter of trees along that line. Based on the 2000 aerial and ground surveys, the areas having the largest concentrations of beetles are located in Forbes, Beaver, and Bulldog Gulches. In particular, the south side of Beaver Gulch and north-central portion of Beaver Gulch has very large pockets, with some spots exceeding 500 killed trees. The central portion of Forbes Gulch has even larger pockets of currently and previously infested trees, some in excess of 1000 trees.

The cumulative tree mortality for transect 14 on the north side of Forbes Gulch essentially equaled the number of trees growing in that area. The discrepancy between the greater number of trees killed per acre (291 TPA) than were growing there (254 TPA) was caused by the estimate of TPA on the site originates from the variable radius plots and therefore will not exactly match the TPA for the whole 8 acres surveyed. The ground surveys also detected substantial numbers of currently infested trees on the south side of Forbes Gulch (transect 19). In addition, moderately large pockets of infested trees, up to 100 trees, can be found scattered throughout the remaining area. The average DBH ranged from 9.9 inches to 14.7 inches and the average basal area ranged from 80 to 164 square feet per acre. This combination of tree size and stand density provide suitably sized material for beetle infestation and are characterized as moderate to high beetle hazard. Additionally, having these conditions occur over such a large and contiguous area as in Beaver Park lends itself to the continuation of a large-scale beetle epidemic.

Predicting mountain pine beetle spread and cumulative mortality over the course of an outbreak is difficult to accomplish. The amount of tree mortality from our transect lines is conservative in that only mortality that has occurred in the last three years (1998, 1999, and 2000) was accounted for and the outbreak is by no means over. The outbreak is continuing to increase over the landscape. Obviously, there was some tree mortality in prior years that was not accounted for, and mortality is still increasing. Based on the last 3 years, however, the range of mortality on a transect line ranged from 3-100 % of the average trees per acre. The lower end of the range is in the areas farthest away from the core infestation in the center of the Beaver Park Roadless area with the high end being in the center of Forbes Gulch, where beetle activity has been the most intense over the last three years. The final impacts will not be known until the epidemic subsides.

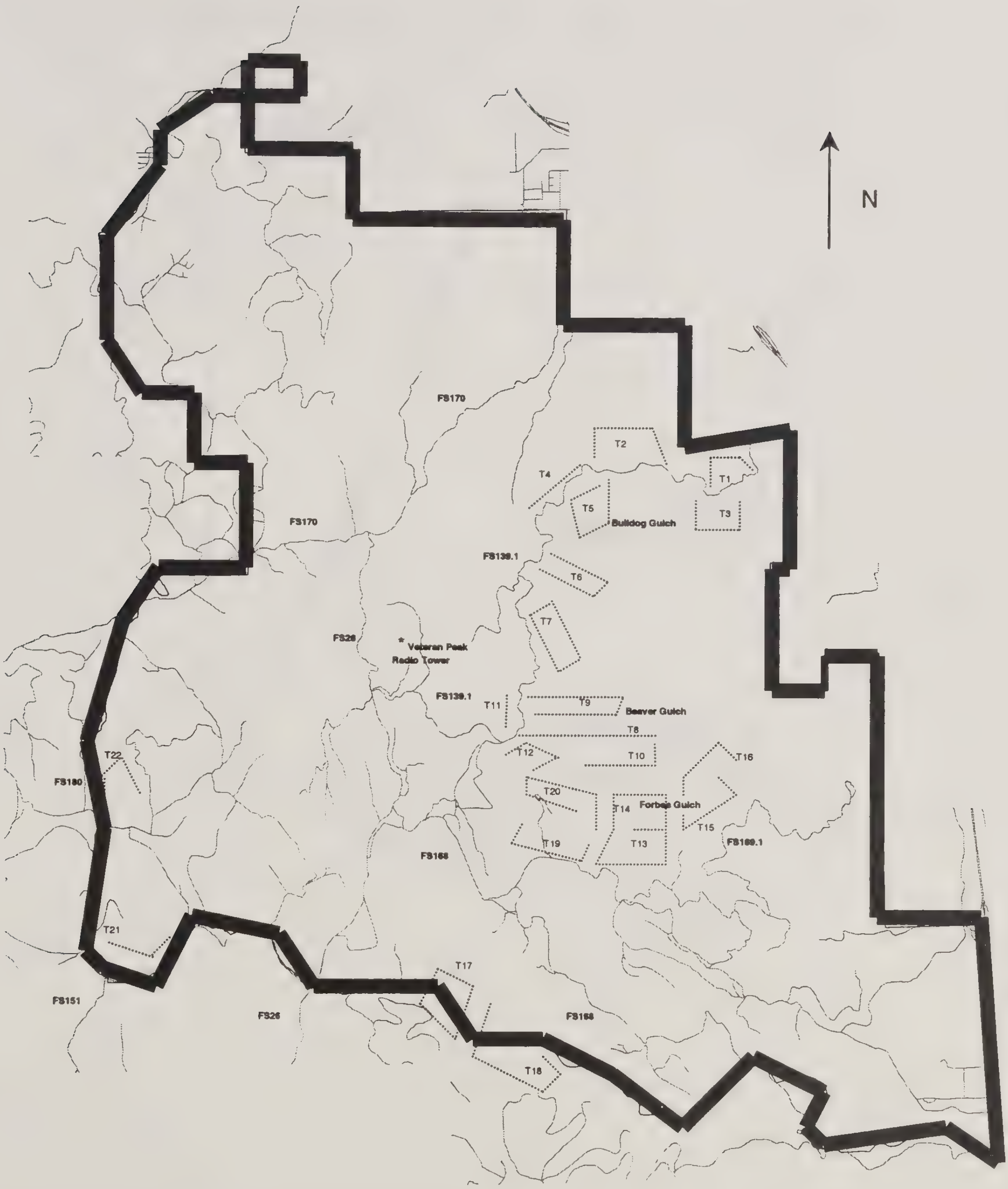


Figure 1. Mountain pine beetle transect lines (dashed lines) relative to forest road system (light solid lines) and local landmarks in the Beaver Park analysis area (heavy solid line).

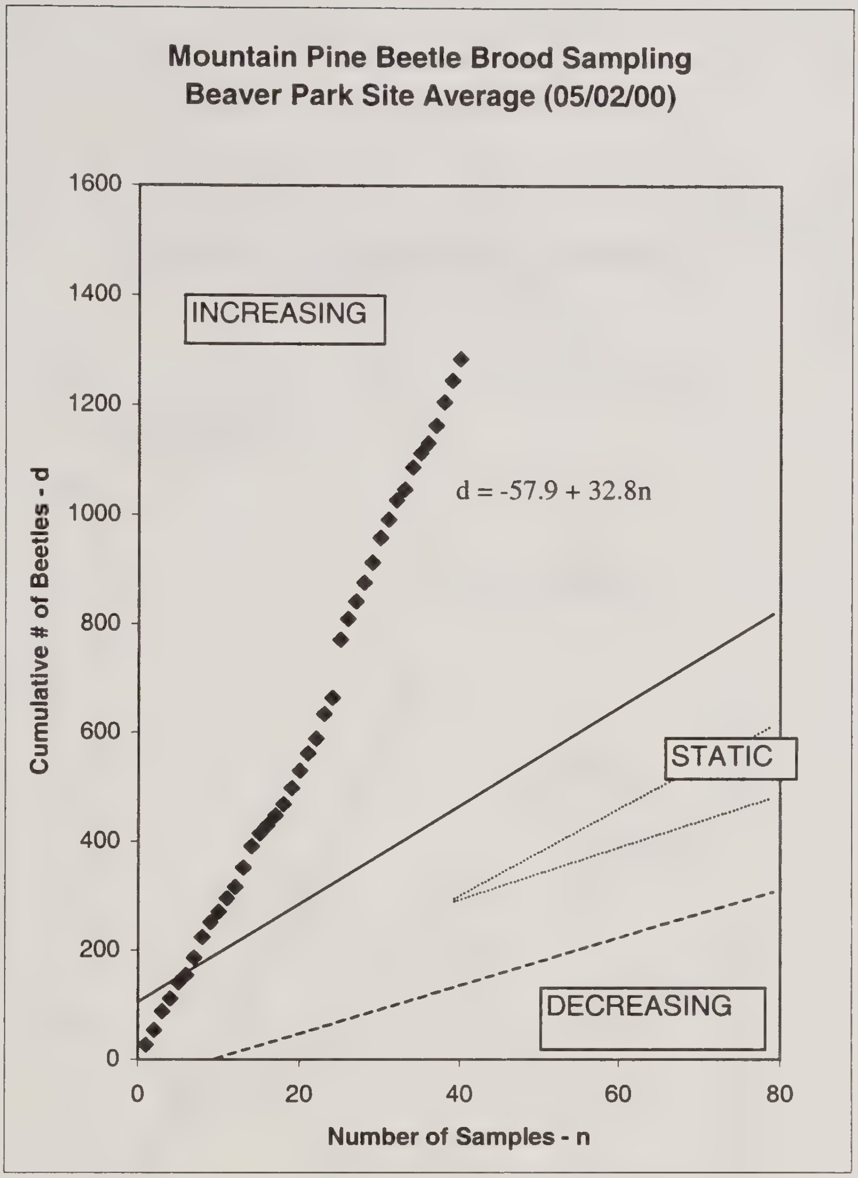


Figure 2. Sequential sampling of mountain pine beetle brood conducted on 2 May 2000. Data points are sample averages from four sites within the Beaver Park area.

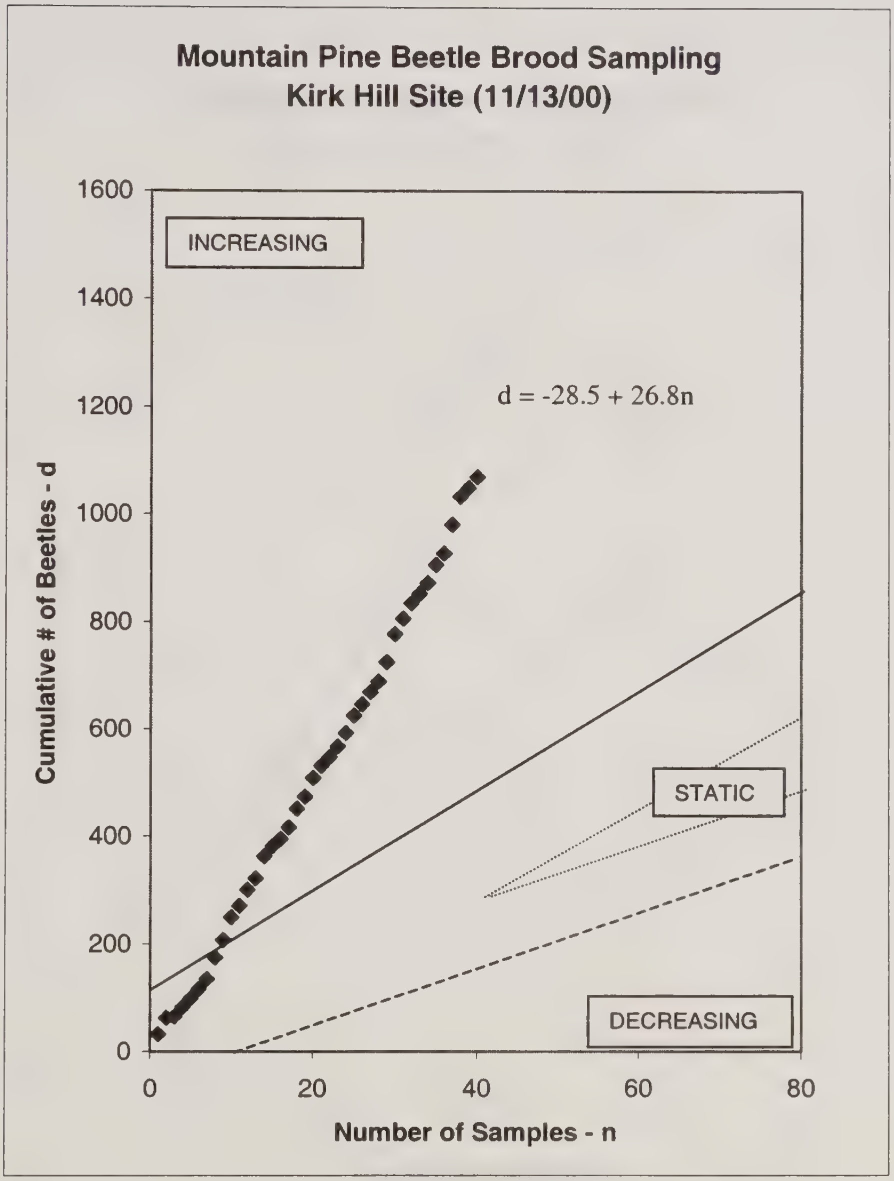


Figure 3. Sequential sampling of mountain pine beetle brood conducted on 13 November 2000. Data points are samples collected from the Kirk Hill area east of Beaver Park.

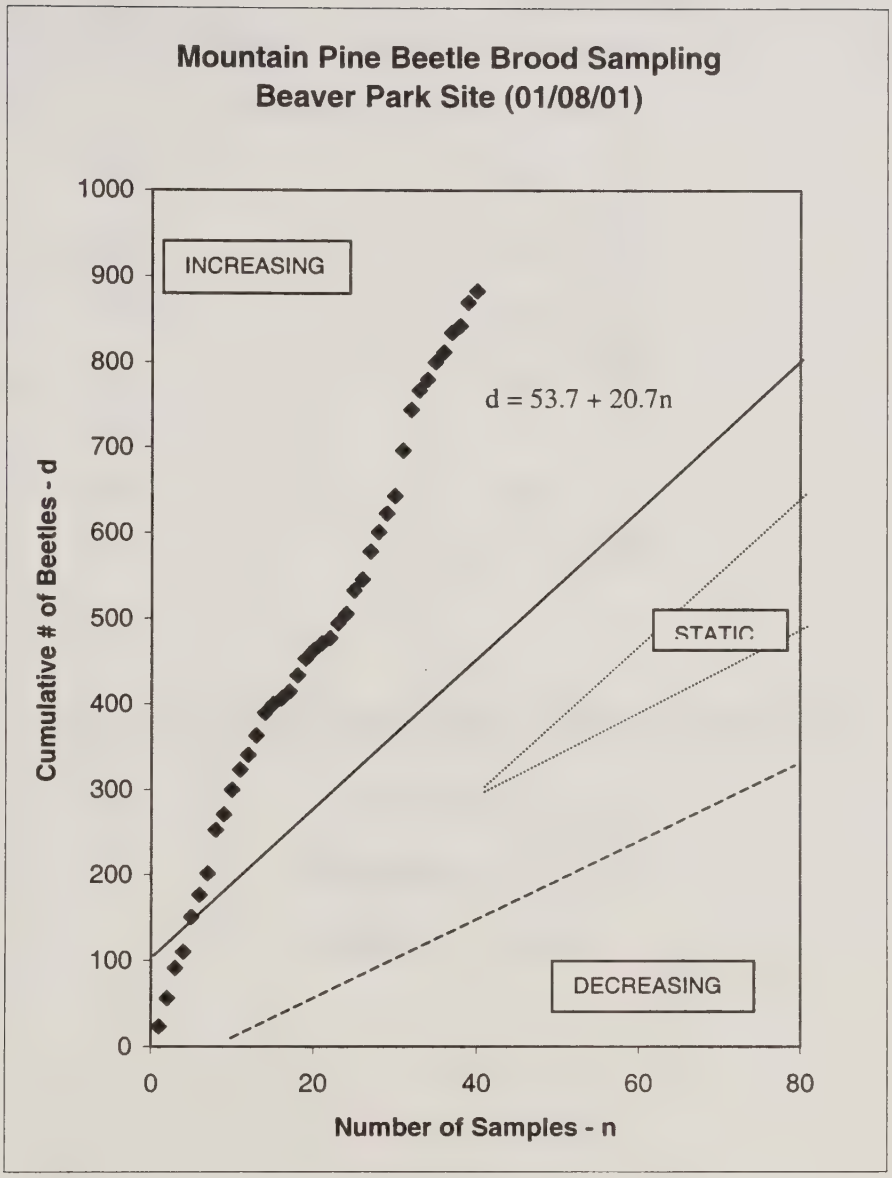


Figure 4. Sequential sampling of mountain pine beetle brood conducted on 8 January 2001. Data points are samples collected along FR139 in Beaver Park.

Table 1. Number of mountain pine beetle attacked trees along 41.75 miles of transect lines in the Beaver Park Analysis Area, Northern Hills Ranger District, and the ratio of attack frequency between years.

	Number of Trees Attacked	
Year	Total Trees Attacked (190 acres)	Attacked Trees Per Acre
1998 Dead	751	4.0
1999 Dead	2235	11.8
Green Infested	4800	25.2
2000 Pitchouts	81	0.4
All Attacks 1998-2000	7867	41.4

RATIO OF ATTACK FREQUENCY BETWEEN YEARS

1998:1999 -- 1:3

1999:2000 -- 1:2.1

1998:2000 -- 1:6.4

Table 2. Number of trees attacked per acre by mountain pine beetle along with average tree diameter, basal area, and trees per acre by transect line in the Beaver Park Analysis area.

Line	Killed trees per acre, attacked in				Mean DBH	Mean BA	Mean Trees/Acre	%TPA
	1998	1999	2000	Total				Dead
1	0.8	1.5	3.4	5.7	10.8	140	212	3
2	3.2	2.9	12.5	18.6	10.0	146	256	7
3	0.7	0.3	4.8	5.8	9.8	93	170	3
4	1.4	1.6	5.0	8.0	11.8	155	191	5
5	4.4	4.6	6.3	15.3	11.1	160	225	7
6	6.3	5.7	5.0	17.0	10.9	164	231	8
7	3.3	11.8	51.3	66.4	10.4	120	194	34
8	6.3	20.0	15.4	41.7	11.5	128	159	27
9	1.3	5.6	13.2	20.1	12.0	136	162	12
10	3.5	10.8	21.8	36.1	13.5	125	117	32
11	1.5	8.0	25.3	34.8	14.7	80	66	53
12	4.7	6.7	20.8	32.2	12.0	153	178	19
13	6.8	27.1	69.8	103.7	11.5	158	204	52
14	15	112.4	163.8	291.2	9.9	145	254	100
15	3.0	5.4	11.3	19.7	11.5	160	200	10
16	6.6	9.6	51.1	67.3	13.1	118	155	43
17	3.0	7.7	11.9	22.6	13.3	120	122	19
18	5.3	6.9	35.2	47.4	13.7	114	109	43
19	4.0	7.3	2.3	13.6	11.1	125	176	8
20	5.3	10.2	33.2	48.7	10.8	126	194	25
21	0.6	1.9	3.7	6.2	11.7	120	156	4
22	3.0	6.3	22.9	32.2	10.1	118	206	16
Avg.	**4.0**	**11.8**	**25.2**	**41.4**	**11.6**	**132**	**179**	**24**

Bear Mountain

Although the overall total tree mortality was relatively low compared with Beaver Park, there was an increase in the number of trees killed per acre each of the last three years in the Bear Mountain area (Table 3). Based on the more than 8 trees killed per acre over the last 3 years and that more than 50 % of this tree mortality was comprised of currently infested trees, mountain pine beetle is at the increasing population phase. In addition, based on the average stand basal area and tree diameter, most of the area is dominated by highly susceptible stands. Brood sampling in this area also suggests that beetle populations are increasing (Figure 5). Less than 5 % of the brood in the sampling process had sustained mortality from cold temperatures.

Table 3. Number of trees attacked per acre by mountain pine beetle, basal area (BA), average tree diameter (DBH), and trees per acre (TPA) by transect near Bear Mountain, Black Hills National Forest.

	TREES KILLED PER ACRE									
Line	**1998**	**1999**	**2000**	**Pitch Out**	**Total**	**Acres**	**Mean DBH**	**Mean BA**	**Mean TPA**	**%TPA Killed**
1	0.38	1.25	1.75	0.0	3.38	8	10.6	107.5	173.0	1.9
2	0.5	1.63	3.88	0.0	6.0	8	9.4	122.5	255.0	2.3
3	2.63	5.75	8.38	0.25	17.0	8	9.9	150.0	272.0	6.3
4	0.67	1.33	4.33	0.0	6.33	6	10.1	146.7	257.0	2.5
Mean	**1.04**	**2.49**	**4.58**	**0.06**	**8.18**	**7.75**	**10.0**	**131.68**	**239.3**	**3.3**

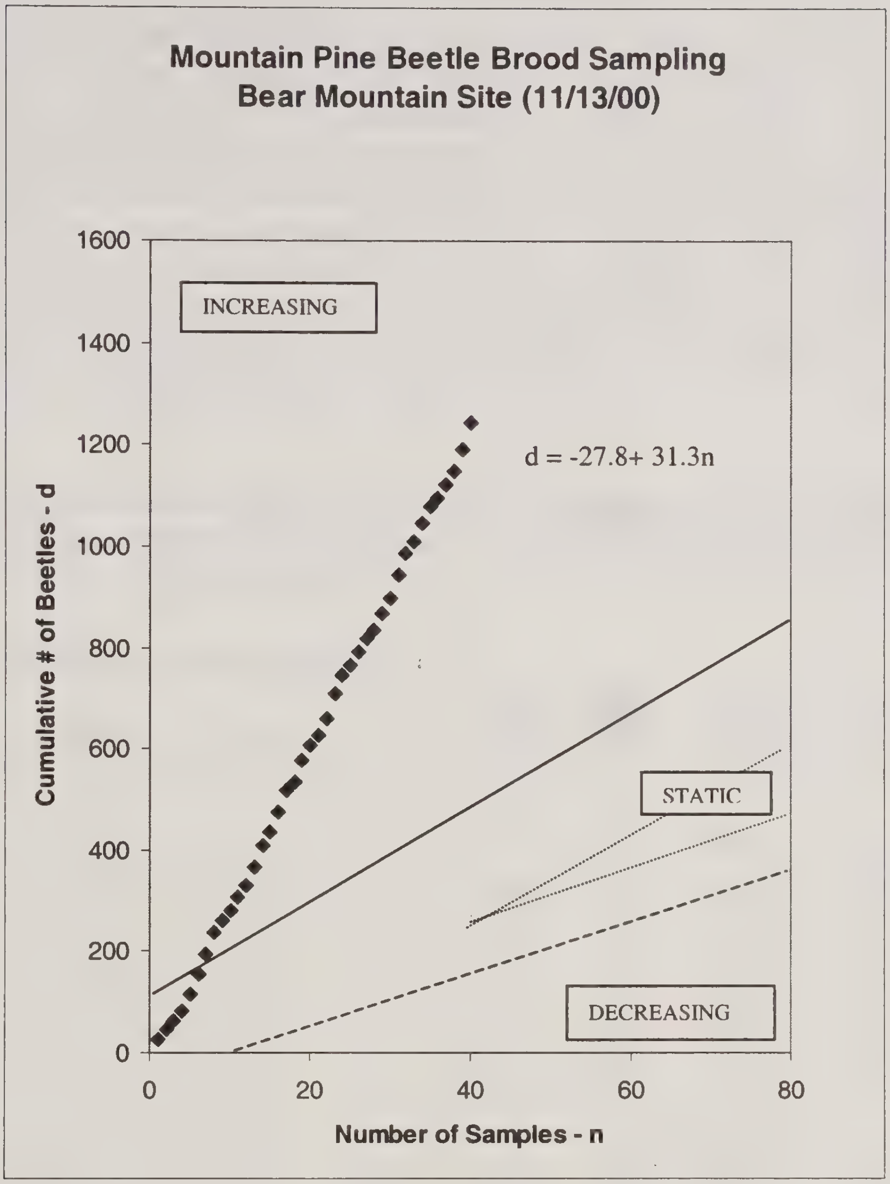


Figure 5. Sequential sampling of mountain pine beetle brood conducted in November 2000. Data points are samples collected from the Bear Mountain Lookout area.

Steamboat Rock

The 1999 ground surveys within the Steamboat Rock area found both fewer currently infested trees and a lower total number of trees killed than were reported in the 1998 biological evaluation (Allen and McMillin 1998). In this year's survey, however, there was a noticeable increase in currently infested trees along the south and north side of Nemo Road (transects 4 and 5). Brood sampling on the south side of Nemo Road suggests that beetle populations are increasing in this area (Figure 6). In addition, approximately 25 percent of the brood were callow adults. This indicates that the adults in 2001 may emerge earlier than normal in this area. Relatively high levels of beetle-killed trees were found in the Erskine Gulch area as well. Stands in this area also had high basal area. There seems to be a declining beetle population along FS149 (transects 1 and 3). Salvage and sanitation harvesting in combination with beetle-caused mortality has decreased basal area in this area.

Table 4. Number of trees attacked per acre by mountain pine beetle, basal area (BA), average tree diameter (DBH), and trees per acre (TPA) by transect near Steamboat Rock area, Black Hills National Forest.

	TREES KILLED PER ACRE								
Line	**1998**	**1999**	**2000**	**Total**	**Acres**	**Mean DBH**	**Mean BA**	**Mean TPA**	**Percent TPA Killed**
1	1.88	1.88	1.0	5.11	8	10.7	123	189	2.7
2	0.88	1.38	3.13	5.94	8	11.4	107.5	147	4.0
3	0.25	0.88	0.13	1.38	8	11.4	135	180	0.8
4	3.6	6.4	13.5	25.49	10	10.6	112	172	14.8
5	0.5	1.63	7.88	11.19	8	15.1	97.5	74	15.1
6	0.38	0.5	0.38	1.36	8	13.0	95	100	1.4
7	2.5	3.88	1.75	8.83	8	11.7	137.5	179	4.9
8	0.25	1.13	2.88	4.75	8	9.3	117.5	235	2.0
9	0.17	0.75	0.92	1.97	12	10.1	120	210	0.9
Mean	**1.15**	**2.04**	**3.5**	**7.33**	**8.67**	**11.48**	**116.1**	**165.1**	**5.19**

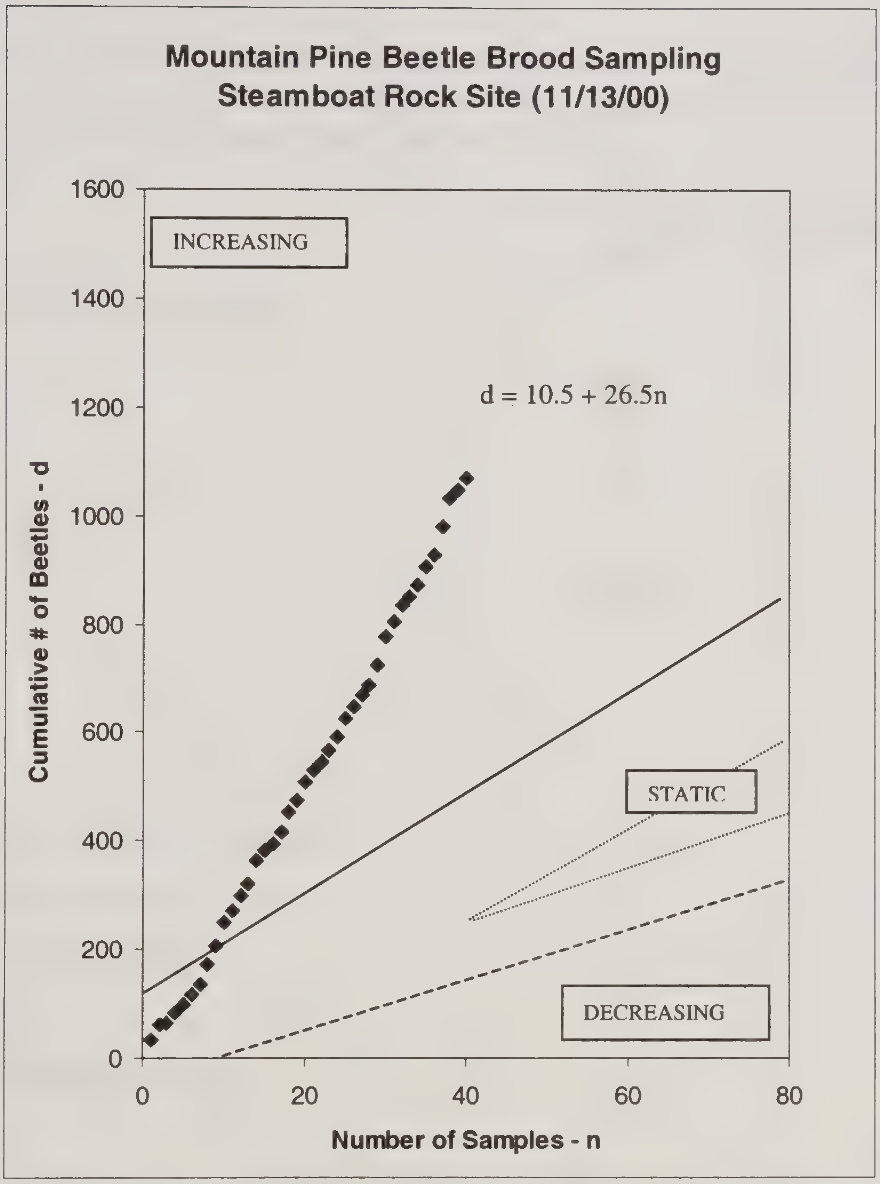


Figure 6. Sequential sampling of mountain pine beetle brood conducted in November 2000. Data points are samples collected from the Steamboat Rock area.

Recreation Areas

Relatively few currently infested trees were found in the ground surveys of recreation sites at Pactola Lake, Sheridan Lake and Deerfield Lake (Table 5). Sanitation removal of infested trees over the last 2 years has probably contributed to the decrease in the number of currently infested trees.

Table 5. Number of trees attacked by mountain pine beetle according to the number of tress attacked in 1999 and 2000 and location of attacked trees in the Sheridan and Pactola Lake campgrounds, Black Hills National Forest.

Location	**Number of trees attacked**		
	2000	**1999**	**Pitchouts**
Sheridan Lake Recreation Area			
Site 2 and 13	1*	0	0
Site 113	0	0	1
Site 37	1**	0	0
Site 39	0	0	1
Site 60 and 61	1	0	1
Site 77	0	1	0
Site 80	0	0	2
Site 89	1*	0	0
North Beach Picnic Ground 1st Pullout	2	1	0
Dakota Point Picnic Area	0	3	0
Jenny Gulch Picnic Ground			
North side of road	0	2	0
Deerfield Lake Recreation Area			
Site 3	0	1	0
Site 6 and 7	0	2	0
Site 14	1	3	0
Site 15	3*	0	0
Site 28	0	1	0
Site 30	1	1	0

*Snap off with mountain pine beetle
**Red turpentine beetle

CONCLUSIONS

Beaver Park

The high number of trees killed per acre found in Beaver Park is approaching totals that are above and beyond those reported for previous outbreaks in the Black Hills. The number of trees per acre attacked in 1 year has been as high as 26.8 on the Spearfish District in the beetle epidemic of the 1970's (Creasap and Minnemeyer 1976) and 61.4 in the Bear Mountain/Whitehouse Gulch area in the early 1990's (Pasek and Schaupp 1992). The number of killed trees from certain areas within the Beaver Park area is already above these reports and still climbing. At this point, it is obvious that entire hillsides are going to be essentially devoid of a ponderosa pine overstory in the near future. There are spots in Beaver Park where every tree had been killed and many of the trees within these spots are green infested trees that will produce beetles next summer. Year-to-year attack ratios of 1:2 or 1:3 are fairly common in population buildups. The overall attack ratio from 1998 to 1999 was 1:2.5; however, there were a number of places where that ratio was 4 or 5 to 1. Stand conditions in this area remain conducive to sustaining high levels of beetle caused mortality, as many stands are still densely stocked with trees that are in diameter classes that the beetles prefer. The areas that are starting to decline in beetle infestation are those where most or all of the overstory has already been killed. All infested trees that were examined had live brood in them, mostly larvae. A general observation from the ground surveys was that there was some woodpecker activity throughout the area. Woodpeckers are a natural enemy of the beetles that eat insects under the bark. Although woodpeckers typically forage for woodborer larvae that follow mountain pine beetle, they also eat some mountain pine beetle larvae. At this point it is unknown what percentage of the beetles will overwinter successfully; however, with the high number of new attacks there should be plenty of new beetles to continue to fuel outbreaks in 2001.

Mountain pine beetle has reached and sustained outbreak proportions in the Beaver Park area. Currently, there are extensive pockets of mortality and the population is still building. Dramatic changes on the landscape have already occurred and additional changes can be expected in the next few years as mortality continues to increase. Any of the areas surrounding Beaver Park that contain suitable host material are also at risk to sustaining losses over the next few years. How high the mortality level will reach is hard to predict; however, in lodgepole pine forests, mountain pine beetle has caused greater than 90% mortality in trees over 5 inches in diameter in uncut (generally greater than 120 basal area) stands (McGregor et al. 1987). Although it is a different tree species, this certainly describes stand conditions in much of the Beaver Park area. In ponderosa pine in the Black Hills, it was estimated that around 80% of susceptible trees had been killed in portions of the Bear Mountain area in the late 1980's and early 1990's (Pasek and Schaupp 1992). Again, stand conditions in this area were similar to those currently found in Beaver Park. McCambridge and others (1983) found that greater than 50% of heavily attacked stands of ponderosa pine were killed in Colorado. The final totals for mortality in the Beaver Park should equal or surpass the 50% level in moderate or high risk stands, and more than likely will approach the 80% level. A final

point on the Beaver Park area, which includes Veteran Peak, is that the Town of Sturgis Municipal watershed and the Ft. Meade watershed are in this general area. If these areas sustain high levels of mortality, the effects on these watersheds are unknown.

Bear Mountain
Mountain pine beetle is increasing in several areas around Bear Mountain. Stand conditions in this area will continue to support beetle populations in the next few years. Effects of this rising population can be expected to be similar to what occurred in the early 1990's in the Bear Mountain Basin (Pasek and Schaupp 1992).

Steamboat Rock
Although beetle populations continue to be at endemic or static population levels adjacent to FS149, a large number of currently infested trees were recorded on both the south and north sides of Nemo Road in the vicinity of the Steamboat Rock picnic grounds. Populations also remain relatively high in the Erskine Gulch (FS147) area near Steamboat Rock.

Recreation Areas
Although relatively few currently infested trees were found in the recreation site surveys, several red and fading trees were observed along the entryways to Dutchman and Whitetail Campgrounds at Deerfield Lake. Inspection of these trees indicated that both *Ips* and mountain pine beetles were active in these trees.

Other Areas of Concern
In addition to the areas surveyed this year, the 2000 aerial survey and ground observations point to other areas of increasing beetle activity. These areas are adjacent to Ditch Creek Road, areas west of Deerfield, and the Boles Canyon area.

ALTERNATIVES

There are a number of actions that can be used to reduce the impacts of mountain pine beetle in this area. These actions fall into two categories: direct action against the beetles themselves or indirect action that addresses the general stand conditions. Direct action deals with the symptoms, too many beetles in one place at one time, and is aimed at directly reducing the number of beetles present. Indirect action focuses on the cause of the problem, which relates to optimal stand conditions for beetle buildup and outbreak.

The only effective long-range strategy to minimize beetle-caused mortality is controlling stand conditions through silvicultural means over entire landscapes and constant monitoring for areas of beetle buildup.

Alternative 1: No Action. Accept that mountain pine beetle-caused tree mortality and the impacts associated with it as a natural process. The extent of the damage to the stands in this area and surrounding areas is difficult to estimate, but there will be changes in the forest caused by beetles. If stand conditions optimal for beetle outbreaks exist, the impacts can be expected to be similar to those described in the conclusion section.

Where to use: Use where other alternatives are not desired or cannot be used.

Advantages: There is no mechanical site disturbance. There will be an increase in the amount of light getting to the forest floor, so that understory species and regeneration may be enhanced. Habitat for some wildlife species may be enhanced by decreasing crown closure and creation of standing dead trees.

Disadvantages: This alternative allows beetle populations to increase and spread to other trees and surrounding areas. There is a loss in timber revenues from either not harvesting beetle-killed trees or letting the infestation grow and increasing the amount of killed timber. Fire hazards can increase with an increase in dead material, including red, dry needles. Visual and recreation values can be negatively affected. The loss of overstory tree cover can have a negative effect for some wildlife species. Regeneration can be impeded as dead trees fall and cover or shade the forest floor.

Alternative 2: Silvicultural Treatments. These are forest management actions that increase tree vigor and reduce stand susceptibility to beetle attack through reducing basal or controlling other stand conditions. They are preventative treatments that should be completed prior to stands experiencing beetle outbreaks. In the Black Hills, stands that are less than 80 square feet of basal area per acre with average stand diameters below 7 inches are at the lowest risk. When treating stands, care must be taken to avoid leaving pockets of dense trees in an otherwise thinned stand.

Where to use: This is a preventative strategy and should be used regularly when planning timber harvests. It is not a tool in stands currently experiencing a beetle outbreak.

Advantages: Controlling stand conditions can reduce overall stand susceptibility to beetle infestation. It does not guarantee that beetle caused mortality will be eliminated; it creates conditions that are less likely to experience a beetle outbreak. It maximizes the economic return from timber sales, as cutting is done prior to mortality taking place. Although the forest will experience mortality through time, treating stands silviculturally allows the decisions on what the forest will look like in the future through the types of harvesting done. If not, the beetles will decide what the forest will look like in the future through their actions, and this may be considerably different than management goals.

Disadvantages: This action is not suitable for areas where timber harvest is not feasible. There is the site disturbances associated with timber harvest while the cutting is being done.

Alternative 3: Sanitation/Salvage Harvest. Sanitation harvesting involves removing currently infested pines prior to the beetle maturation and emergence. It requires the removal of green trees that have live brood in them. These green trees are already dead, however, the foliage will not change color until the following summer. Trees removed in a sanitation harvest are treated; either moved to at least one mile from the nearest live host type or processed at the mill, prior to beetle emergence. Salvage harvest involves the removal of beetle-killed trees that do not have live beetles in them. These trees have already changed color; their needles are either red or gone.

A relatively new approach to the sanitation of bark beetles includes the use of semiochemicals (e.g., pheromones produced by the beetles for aggregation or anti-aggregation behavior). One method that is used in combination with traditional sanitation practices involves baiting trees with aggregation pheromones in concentrated areas or on a grid system just prior to the adult flight period. After the trees are infested, the trees **must** be removed and treated as stated above. A spillover effect (i.e., trees adjacent to the baited trees are also attacked) is commonly experienced when using this technique, and these neighboring trees also must be removed and processed if attacked. The amount of spillover depends on the local population level of beetles.

Where to use: Stands susceptible to mountain pine beetle that are currently under attack where it is desirable to reduce mountain pine beetle populations and recover timber resource value. Also appropriate where beetle populations threaten currently uninfested nearby stands.

Advantages: Mountain pine beetle populations can be reduced in localized areas and in individual stands by removing most of the currently infested trees. This can provide some protection to surrounding uninfested trees and stands by removing a large source of attacking beetles. Timber values are recovered that would otherwise be lost or degraded. Fuel loading and fire hazard can be reduced by removal of much of the dead

needles and timber. Regeneration can be enhanced through overstory removal and site disturbance.

Disadvantages: This alternative has a short implementation time. Areas must be marked and cut prior to beetle flight, i.e., before the end of June. Sanitation will not be effective on a large scale. It is only effective at suppressing beetles at the stand level and so will not work on a landscape level or when there is a chance of beetles re-infesting the treated area. Site disturbance that accompanies timber harvest occurs.

Alternative 4: Infested Tree Treatment. Cut and individually treat infested trees prior to beetle emergence. The action should kill most or all of the beetles within the cut trees. Examples of treatments include: cut and burn on site, cut and bury at least 6 inches on site, cut and chip, cut and debark. The use of beetle aggregation pheromones could be used in conjunction with this option to contain beetle spots to be treated.

Where to use: This is most appropriate for treating small spots in areas where high value resources are nearby. It can be used in areas that are unroaded or too steep for conventional sanitation or salvage harvesting.

Advantages: Beetle populations can be reduced or eliminated from the treated area. This can provide some relief to surrounding uninfested stands and trees. The site disturbance is less than in conventional harvesting operations. Regeneration can be enhanced through the removal of overstory trees. Fire hazard can be reduced.

Disadvantages: The implementation time for this alternative is short. Treatments must be done after new infested trees are located and prior to beetle flight. This treatment only reduces beetle pressure in a small area; it is not effective on a landscape scale. This treatment does nothing to address stand conditions that led to beetle buildup in the first place.

Alternative 5: Protection of High Value Trees. Prior to beetle emergence in the summer, the stems of high value uninfested trees are treated with a registered insecticide.

Where to use: On trees around residences, in campgrounds, or other high value areas. Trees must be of significantly high value and be under heavy beetle pressure to justify treatment costs.

Advantages: This action is very effective at protecting individual trees from becoming infested.

Disadvantages: Insecticide application does not effectively reduce beetle populations or address the cause of the outbreak. It does not guarantee protection; application must be thorough for it to be effective. Many people have concerns regarding environmental contamination when using pesticides. It is extremely expensive on a large scale and, therefore, is only appropriate for a single or a few high value trees.

RECOMMENDATION

Beaver Park

All alternatives are recommended depending on the site and suitability. The beetle population has risen to a point where any and all actions should be considered in this area or population spread will continue and cause mortality in surrounding areas.

Alternative 1: The do nothing alternative may be chosen out of necessity in some of the most remote areas and those with steeper slopes. This alternative would allow continued beetle buildup and its associated mortality. This mortality may be extensive in some areas that go untreated.

Alternative 2: Silvicultural treatments (i.e., reducing basal area through thinning), is best used during long range planning processes. Stands in this area that can be manipulated need to have this done on a regularly scheduled basis to avoid future outbreaks. At this point, most of the silvicultural planning for the core of this area is too late. This would be most useful in nearby surrounding stands around the perimeter.

Alternative 3: Sanitation and salvage logging, is highly recommended in those areas where it is possible. Removal of beetle-infested trees would need to be carried out in a short time frame, before the middle of July 2001 when the beetles would start to fly. At the very least, these types of operations ought to be carried out around the perimeter of the infested area where beetle populations exist in an effort to confine the outbreak in the Beaver Park area. In some of the gulches within this area, sanitation/salvage logging may be difficult and would likely result in some areas that are essentially clearcut because nearly every tree has been killed in the last few years or is currently infested.

Because of other considerations, use of infested tree treatments should be considered, especially in high profile areas. These treatments can be used to kill overwintering beetles, thereby reducing the emerging beetle population. This alternative is probably not appropriate over the entire Beaver Park area, but could be very useful in localized spots. Consideration should be given to using mountain pine beetle pheromones in conjunction with these treatments.

The use of protective sprays should be used only in very high value areas. These sprays could also be used in conjunction with aggregation pheromones, although this would only be on an experimental basis.

If there are no treatments carried out in this area, beetle populations will continue to grow and mortality will increase. The extent of damage that will occur and how long it will continue are difficult to state at this point in time; however, stands that are in close proximity to this area will remain at risk. The forest in the core of the Beaver Park area has already been significantly affected and changed, and there is a good likelihood that this epidemic will continue to expand and cause similar damage in surrounding areas.

Bear Mountain area
Alternatives 2, 3 and 4 are recommended depending on the management focus of different stands. Beetle populations showed an increase compared with last year and favorable stand conditions exist in this area. Therefore, the potential for significant tree mortality to occur in this area exists over the next few years.

Steamboat Rock
The sanitation/salvage activities completed in 1998, in combination with commercial thinning, seem to have reduced beetle populations throughout much of this area. Continued sanitation should be done to reduce beetle populations further and protect the remaining stands. Areas of special concern include stands west of Erskine Gulch along FS144.1A, and along Nemo Road near the Steamboat Rock picnic ground. The area west of Erskine Gulch contains many stands having high basal areas and a building population of beetles. A combination of alternatives 2 (thinning), 3 (sanitation), and 4 (infested tree treatment) would be appropriate in this area.

Pactola Lake & Sheridan Lake areas
The continuation of sanitation/salvage practices is recommended in the campgrounds. Of particular importance is the sanitation of green infested trees. This will reduce the population of beetles in the campgrounds proper, thereby removing a local source of re-infestation. Removal of standing dead (salvage) could also be accomplished at this time, as a means of reducing potential future hazard trees in the campgrounds. Alternative 2 should be considered for the campgrounds and surrounding areas in the future. Alternative 5, protection of high value trees, should be considered for specific, high value trees.

Deerfield Lake area
Similar to the Pactola and Sheridan Lake areas, annual monitoring of campgrounds, day use lands, and surrounding areas will be needed over the next few years in the face of beetle population increase throughout this portion of the Black Hills. A combination of alternatives 2, 3, 4, and 5 may be warranted depending on site and suitability.

REFERENCES

Allen, K.K. 1998. Evaluation of mountain pine beetle activity in the Kine Analysis Area of the Black Hills National Forest. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-98-05.

Allen, K.K. and J. D. McMillin. 1998. Evaluation of mountain pine beetle activity in the Steamboat Rock and Beaver Park areas on the Northern Hills Ranger District of the Black Hills National Forest. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-99-01.

Allen, K.K. and J. D. McMillin. 1999. Evaluation of mountain pine beetle activity in the Beaver Park areas on the Spearfish/Nemo Ranger District of the Black Hills National Forest. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-00-01.

Bellows, T.S., C. Meisenbacher and R.C. Reardon. 1998. Biological control of arthropod forest pests of the western United States: A Review and Recommendations. USDA Forest Service, Forest Health Technology Enterprise Team-Morgantown, WV. FHTET-96-21.

Bentz, B.J. and D.E. Mullins. 1999. Ecology of mountain pine beetle (Coleoptera: Scolytidae) cold hardening in the intermountain west. Environ. Entomol. 28: 577-587.

Creasap, V.L. and C.D. Minnemeyer. 1976. Mountain pine beetle, Black Hills of South Dakota and Wyoming, Black Hills National Forest and adjacent state and private lands of South Dakota and Wyoming. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-76-8.

Knight, F.B. 1960. Sequential sampling of Black Hills beetle populations. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Note, RM-48.

McCambridge, W.F., F.G. Hawksworth, C.B. Edminster, and J.G. Laut. 1982. Ponderosa pine mortality resulting from a mountain pine beetle outbreak. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Paper RM-235.

McMillin, J.D. and K.K. Allen 1998. Evaluation of mountain pine beetle activity in the Blackhawk Timber Sale area and the Pactola and Sheridan Lake campgrounds on the Pactola/Harney Ranger District of the Black Hills National Forest. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-99-04.

McMillin, J.D. and K.K. Allen 1999. Evaluation of mountain pine beetle activity in the Black Hills National Forest. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-00-03.

Pasek, J.E. and W.C. Schaupp. 1992. Status and trends of mountain pine beetle populations in the Bear Mountain and White House Gulch areas of the Harney Ranger District, Black Hills National Forest, South Dakota. USDA Forest Service, Rocky Mountain Region, Biological Evaluation R2-92-04.

Obedzinski, R.A., J.M. Schmid, S.A. Mata, W.K. Olsen, R.R. Kessler. 1999. Growth of ponderosa pine stands in relation to mountain pine beetle susceptibility. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-28.

Samman, S. and J. Logan, tech. eds. 2000. Assessment and response to bark beetle outbreaks in the Rocky Mountain area. Report to Congress from Forest Health Protection, Washington Office, Forest Service, USDA Forest Service General Technical Report RMRS-GTR-62. 46 p.

Schmid, J.M. and S.A. Mata. 1992. Stand density and mountain pine beetle-caused tree mortality in ponderosa pine stands. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Note RM-515.

Schmid, J.M., S.A. Mata and R.A. Obedzinski. 1994. Hazard rating ponderosa pine stands for mountain pine beetles in the Black Hills. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Note RM-529.

Schmid, J.M., S.A. Mata, W.K. Olsen, and D.D. Vigil. 1993. Phloem temperatures in mountain pine beetle-infested ponderosa pine. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Note RM-521.

Stevens, R.E., W.F. McCambridge and C.B. Edminster. 1980. Risk rating guide for mountain pine beetle in Black Hills ponderosa pine. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Note RM-385.